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ECO-FRIENDLY MANAGEMENT OF LATE BLIGHT OF TOMATO (*LYCOPERSICON ESCULENTUM* L.)

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ABSTRACT

The study was proposed to evaluate the "Eco-friendly management of late blight of tomato (*Lycopersicon esculentum* L.).The pots experiment was conducted on Research field of Department of Plant pathology, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad in winter Season of 2013-2014. Eleven treatments including control with four replications were analyzed in R. B. D which included, untreated control, Neem oil 2.5 g/kg soil treatment (ST) + 7g/l foliar spray (FS), carbendazim 2.5g/kg (ST)+ 4g/l (FS), *Pseudomonas fluorescens* 2.5/kg (ST) + 5g/l (FS), *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FS), *Pseudomonas fluorescens* + *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FS), Neem cake powder 2.5g/pot (ST), carbendazim 2.5g/kg (ST)+ 4g/l (FS) + neem cake 2.5g/pot(ST), neem cake 2.5g/pot ST + (*Trichoderma* harzianum)2.5/kg ST + 5g/l FS, (neem cake) 2.5g/pot(ST) + (*Pseudomonas fluorescens*) 2.5/kg (ST) + 5g/l (FT), neem cake 2.5g/pot(ST) + *Pseudomonas fluorescens* + *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FT). All treatments significantly decrease disease severity of late blight as compared to control. Observation for percent disease intensity was recorded at 60, 70, 80 and 90 days after sowing (DAS). Minimum disease intensity was recorded in *Pseudomonas fluorescens* (10.52 %, 18.67 %, 25.25 % and 28.80% respectively) as compared to control which recorded maximum disease intensity (32.90 %, 48.15 %, 52.69 % and 62.77 % respectively). Maximum plant height was recorded in neem cake + *Trichoderma harzianum* (32.62 cm, 49.91 cm, 64.73 cm and 74.85 cm respectively) at 30, 45, 60 and 75 DAS as compared to control which recorded minimum plant height (15.62 cm, 31.57 cm, 43.06 cm and 51.53 cm). All the treatments significantly increased yield per plant, root length, shoot and root fresh and dry weight.

KEYWORDS: Carbendazim, Late Blight, Neem Products, *Pseudomonas fluorescens*, Tomato, *Trichoderma harzianum*

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is a popular vegetable widely grown in the tropics which is an excellent source of vitamin A and vitamin C, minerals like iron and phosphorus **(Villareal, 1979)**. It is one of the most popular vegetable grown in the world next to potato **(Pandey and Rai, 2005)**. Tomato is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily. Tomato belongs to the Solanaceae family. This family also includes other well-known species, such as potato, tobacco, peppers and eggplant (aubergine). Tomato has its origin in the South American Andes. The cultivated tomato was brought to Europe by the Spanish conquistadors in the sixteenth century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. More recently, wild tomato has been distributed into other parts of South America and Mexico. Late blight (LB), caused by the oomycete *Phytophthora infestans* (Mont.) de Bary, is one of the most destructive diseases of tomato as well as potato (*Solanum tuberosum* L.) worldwide, causing significant economic losses annually

(Foolad *et al.* 2008 and Nowicki *et al.* 2012).The pathogen is best known for its role in the Irish potato famine, where it caused the loss of more than a million lives **(Andrivon, 1996)**. When left uncontrolled, *P. infestans* can destroy a tomato or potato crop within several days. The success of *P. infestans* as a pathogen originates from its effective asexual and sexual life cycles as well as its remarkable capacity to rapidly overcome plant resistance genes **(Foolad *et al.* 2008; Nowicki *et al.* 2012)**. The latter feature has led researchers to describe *P. infestans* as a pathogen with a "high evolutionary potential" **(Raffaele *et al.* 2010b)**. Late blight (LB) has been identified as a major disease of tomato and potato and is one of the most devastating plant diseases of all time. An unprotected tomato field can suffer yield losses reaching up to 100% because of LB infection **(Nowicki *et al.* 2012)**. *Phytophthora infestans* – literally, "plant destroyer," in Greek – has been traced back to the same origin as tomatoes and potatoes, that is, the Andean region **(Foolad *et al.* 2008; Vleeshouwers *et al.* 2011)**. The first symptoms usually appear on leaves as water-soaked, oily, pale or dark-green or brown/ black, circular or irregular lesions. Typically, younger, more succulent, tissue is affected first. During periods of abundant moisture, sporulation of the pathogen can be seen by the naked eye as a white, cottony growth on the underside of affected leaves and/ or on fruit lesions. When wet and cool conditions are prevalent, the disease usually progresses rapidly through the plant canopy and crop, resulting in brown, shriveled foliage.

MATERIALS AND METHODS

The experiment was conducted at the research (pots) in the Department of Plant protection at Sam Higginbotton Institute of Agriculture Technology and Sciences, Allahabad. U. P. (India) during the year 2014

Soil Sterilization

Soil sterilized with 2 percent formalin. The formalin solution was mixed with the soil and that was covered with polythene bag for 48 hour. After wards when the trace of formalin smell has gone the soil was worked up thoroughly dried and used into pots.

Pathogenicity Test

The pathogen *Phytophthora infestans* was isolated from infected tomato leaves and stem portion and purified after identification prepared. Koch's postulates were tested to confirm the pathogenicity of the fungus. The healthy tomato plants were sown in the pots, zoospore/sporangial suspensions were used to inoculate tomato foliage and then kept in greenhouse for symptoms appearance. After the symptoms appeared, the suspected pathogen was re-isolated from the diseased portion of infected tomato and the morphological characters of the colony were compared with the earlier isolated fungus and pathogenicity of the fungus was proved.

Details of Treatments and Their Dosages

The study was proposed to evaluate the"Eco-friendly management of late blight of tomato (*Lycopersicon esculentum* L.) caused by *Phytophthora infestans*. The seed was treated with Neem oil 2.5 g/kg soil treatment (ST) + 7g/l foliar spray (FS), carbendazim 2.5g/kg (ST)+ 4g/l (FS), *Pseudomonas fluorescens* 2.5/kg (ST) + 5g/l (FS), *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FS), *Pseudomonas fluorescens* + *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FS), Neem cake powder 2.5g/pot (ST), carbendazim 2.5g/kg (ST)+ 4g/l (FS) + neem cake 2.5g/pot(ST), neem cake 2.5g/pot ST + (*Trichoderma* harzianum)2.5/kg ST + 5g/l FS, (neem cake) 2.5g/pot(ST) + (*Pseudomonas fluorescens*)

2.5/kg (ST) + 5g/l (FT), neem cake 2.5g/pot(ST) + *Pseudomonas fluorescens* + *Trichoderma harzianum* 2.5/kg (ST) + 5g/l (FT). Control pots without treatment (tomato alone).

Disease Intensity

Disease intensity (%) was calculated by used the following formula.

$$\text{Disease index (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total number of rating x Maximum disease grade}} \times 100 \text{ (Wheeler 1969)}$$

Figure 1: Photo Showing Degrees of Infection on 1 to 5 Scale (1. Represent 1- 10% Infected Leaf, 2. Represent 11-20% Infected Leaf, 3. Represent 21-50% Infected Leaf, 4. Represent 51-80% Infected Leaf, 5. Represent 81-100% Infected Leaf)

RESULTS AND DISCUSSIONS

Isolation and Identification of *Phytophthora infestans*

The suspected pathogen was isolated from the leaves of infected tomato plants showing characteristics symptoms and were grown through the tuber slice. Koch's postulates were tested to confirm the pathogenicity of the fungus and inoculated plants showed the typical symptoms of late blight and the characteristics of pathogen was observed under microscope (plate 2 and plate 3) Phytophthora infestans produces microscopic, asexuall spores called sporangia. These sporangia are hyaline (clear), lemon-shaped and 20-40 um long. When placed in water or in very high relative humidity, the cytoplasm in the sporangia divide and many swimming zoospores emerge from each sporangium. Sporangia are formed on specialized branches called sporangiophores. The branched sporangiophore, with swellings at the points where sporangia were attached are distinctive for Phytophthora infestans and useful for identification of this pathogen. In the absence of sufficient water or with temperatures above 24 Co, no zoospores form. However, sporangia germinate by producing germ tubes that penetrate the host.

Figure 2: The Lemon-Shaped Sporangium (Zoospore Containing Structure) of *Phytophthora infestans* on a Sporangiophore (Left) and One Sporangium that is Dislodged (Right)

Figure 3: Sporangiophores of *Phytophthora infestans* from Which All Sporangia Dislodged on Tomato Leaf Tissue

Disease Severity (%)

The data in table 1, revealed that all the treatments were found statistically significant and reduced the disease severity as compared to control. Minimum disease intensity % of late blight of tomato at 60 days after sowing was recorded in *Pseudomonas fluorescens* (10.52), followed by carbendazim (14.35), *Trichoderma harzianum* (17.04), Neem oil (20.71), Neem cake + *Trichoderma harzianum* (21.54), Neem cake (21.82), Neem cake + *Pseudomonas fluorescens* (22.63), Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (24.01), *Pseudomonas fluorescens* + *Trichoderma harzianum* (24.20), Neem cake + carbendazim (27.91), including control (32.90). At 70 DAS the best treatment was *Pseudomonas fluorescens* which had lowest disease intensity (18.67), followed by carbendazim (20.08), *Trichoderma harzianum* (20.83), Neem oil (25.74), Neem cake + *Pseudomonas fluorescens* (27.71) Neem cake + *Trichoderma harzianum* (28.24), Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (29.81), Neem cake (30.41), *Pseudomonas fluorescens* + *Trichoderma harzianum* (31.24), Neem cake + carbendazim (32.57), as compared to control (48.15). At 80 DAS Minimum disease intensity % was recorded in *Pseudomonas fluorescens* (25.25), followed by *Trichoderma harzianum* (26.56), carbendazim (27.72), Neem cake + *Pseudomonas fluorescens* (28.30), Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (30.05), Neem cake + *Trichoderma harzianum* (30.66), Neem cake (31.01), Neem oil (31.93), *Pseudomonas fluorescens* + *Trichoderma harzianum* (32.53), Neem cake + carbendazim (34.06), as compared to control (52.69). At 90 DAS Minimum disease intensity % was recorded in *Pseudomonas fluorescens* (28.80), followed by *Trichoderma harzianum* (29.40),carbendazim (31.04), Neem oil (33.40), Neem cake (33.56), Neem cake + *Trichoderma harzianum* (33.79), Neem cake + carbendazim (35.14),*Pseudomonas fluorescens* + *Trichoderma harzianum* (35.66),Neem cake + *Pseudomonas fluorescens* (38.14),Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (41.31),as compared to control (62.77).

Figure 4: The Disease Intensity on Treatments Control T0, Neem Oil T_1, Carbendazim T_2, *Pseudomonas fluorescens* T_3, *Trichoderma harzianum* T_4 and *Pseudomonas fluorescens* + *Trichoderma harzianum* T_5 at 90 DAS

Figure 5: The Disease Intensity on Treatments Neem Cake T_6, Neem Cake + Carbendazim T_7, Neem Cake + *Trichoderma harzianum* T_8, Neem Cake + *Pseudomonas fluorescens* T_9 and Neem Cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* T_{10} at 90 DAS

Plant Height (cm)

The data presented in Table 1 revealed that all the treatments were statistically significant increased plant height as compared to control. The maximum plant height was recorded at 30 DAS in **T_7** Neem cake + carbendazim (37.97cm) followed by **T_8** Neem cake + *Trichoderma harzianum* (32.62cm), **T_9** Neem cake + *Pseudomonas fluorescens* (29.65cm), **T_{10}** Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (28.47cm), **T_1** Neem oil (24.60cm), **T_2** carbendazim (23.57cm), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (22.39cm), **T_4** *Trichoderma harzianum* (21.22cm), **T_3** *Pseudomonas fluorescens* (20.78cm), **T_6** Neem cake (20.20cm), including T_0 control (15.62cm). At 45 DAS the maximum plant height was recorded in **T_8** Neem cake + *Trichoderma harzianum* (49.91cm), followed by, **T_9** Neem cake + *Pseudomonas fluorescens* (48.19cm), **T_{10}** Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (46.01cm), **T_7** Neem cake + carbendazim (45.81cm) **T_1** Neem oil (44.42cm), **T_6** Neem cake (41.87cm), **T_2** carbendazim (41.03cm), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (40.47cm), **T_4** *Trichoderma harzianum* (40.12cm), **T_3** *Pseudomonas fluorescens* (38.82cm),as compared with T_0 control (31.57cm). The maximum plant height was recorded at 60 DAS in **T_8** Neem cake + *Trichoderma harzianum* (64.73cm), followed by, **T_7** Neem cake + carbendazim (62.05cm) **T_9** Neem cake + *Pseudomonas fluorescens* (60.42cm), **T_6** Neem cake (58.91cm), **T_1** Neem oil (57.08cm), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (56.61cm), **T_4** *Trichoderma harzianum* (55.92cm), **T_{10}** Neem cake + *Pseudomonas fluorescens* +*Trichoderma harzianum* (55.77cm), **T_2** carbendazim (53.75cm), **T_3** *Pseudomonas fluorescens* (51.05cm), including with T_0 control (43.06cm). The maximum plant height was recorded at 75 DAS in **T_8** Neem cake + *Trichoderma harzianum* (74.85cm), followed by, **T_6** Neem cake (71.55cm), **T_7** Neem cake + carbendazim (70.12cm), **T_9** Neem cake + *Pseudomonas fluorescens* (70.05cm), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (67.42cm), **T_4** *Trichoderma harzianum* (66.38cm), **T_1** Neem oil (63.22cm), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (62.85cm), **T_2** carbendazim (61.63cm), **T_3** *Pseudomonas fluorescens* (59.46cm),as compared with T_0 control (51.53cm).

Figure 6: The Effect of Bio Agents, Neem Products and Carbendazim with and without Combination on Plant Height (cm) of Tomato at 75 DAS

T_0 - Control (tomato alone) T_1 - Neem oil T_2 - Carbendazim T_3 - *Pseudomonas fluorescens* T_4 - *Trichoderma harzianum*

T_5 - *Pseudomonas fluorescens* + *Trichoderma harzianum* T_6 - Neem cake T_7 - Neem cake + carbendazim

T_8 - *Trichoderma harzianum* T_9 - Neem cake + *Pseudomonas fluorescens* T_{10} - Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum*

Fresh Shoot Weight (g) at 110 Days after Sowing

The data presented in table 1, revealed most of the treatments were statistically significant increased fresh shoot weight as compared to control. 110 DAS the fresh shoots of tomatoes plants were weighed on an electronic balance. The maximum shoot fresh weight was recorded in **T_8** Neem cake + *Trichoderma harzianum* (54.63g), follows by, **T_6** Neem cake (45.50g), **T_4** *Trichoderma harzianum* (43.81g), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (42.50g), **T_7** Neem cake + carbendazim (41.50g), **T_9** Neem cake + *Pseudomonas fluorescens* (40.75g), **T_2** carbendazim (37.25g), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (35.31g), **T_3** *Pseudomonas fluorescens* (34.19g), **T_1** Neem oil (32.25g), including with T_0 control (26.69g).But T_8,T_6,T_4,T_5,T_7 and T_9 were none significant to each other. T_6, T_4, T_5, T_7, T_9, T_2, T_{10}, T_3, and T_1 found none significant to each other. T_2, T_{10}, T_3, T_1 and T_0 were statistically none significant to each other.

Dry Shoot Weight (g) at 120 Days after Sowing

110 DAS The plants shoots were dried at room temperature. The dry shoot of tomatoes plants were weighed on an electronic balance.The maximum shoot dry weight was recorded in **T_8** Neem cake + *Trichoderma harzianum* (8.19g), follows by, **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (7.19g), **T_4** *Trichoderma harzianum* (7.00g), **T_7** Neem cake + carbendazim (6.88g), **T_9** Neem cake + *Pseudomonas fluorescens* (6.69g), **T_6** Neem cake (6.50g), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (35.31g), **T_2** carbendazim (5.94g), **T_3** *Pseudomonas fluorescens* (5.25g), **T_1** Neem oil (4.56g), compared with T_0 control (2.75g). But T_8,T_5,T_4,T_7,T_9 and T_6 were none

significant to each other.T_5,T_4,T_7,T_9,T_6,T_{10},T_2 and T_3 found none significant to each other. T_6,T_{10},T_2,T_3 and T_1 were statistically none significant to each other.T_1andT_0 found none significant to each other.

Table 1

S.N	Treatments	Disease Intensity (%)				Plant Height (cm)				Fresh Shoot Weight (gm)	Dry Shoot Weight (gm)	Fresh Root Weight (gm)	Dry Root Weight (gm)	Root Length (cm)	Yield Per Plant (gm)
		60 DAS	70 DAS	80 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	110 DAS	120 DAS	110 DAS	120 DAS	110 DAS	110 DAS
T0	Control (tomato alone)	32.9	48.15	52.69	62.77	15.62	31.57	43.06	51.53	26.69	2.75	2.44	0.63	17.24	144.25
T1	Neem oil	20.71	25.74	31.93	33.4	24.6	44.42	57.08	63.22	32.25	4.56	4.12	1.88	24.72	279.5
T2	carbendazim	14.35	20.08	27.72	31.04	23.57	41.03	53.75	61.63	37.25	5.94	6.06	3	20.7	294.31
T3	*Pseudomonas fluorescens*	10.52	18.67	25.25	28.8	20.78	38.82	51.05	59.46	34.19	5.25	4.81	2.38	24.67	256.86
T4	*Trichoderma harzianum*	17.04	20.83	26.56	29.4	21.22	40.12	55.92	66.38	43.81	7	6.75	3.56	29.49	282.56
T5	*Pseudomonas fluorescens + Trichoderma harzianum*	24.2	31.24	32.53	35.66	22.39	40.47	56.61	67.42	42.5	7.19	5.5	2.75	20.98	219.94
T6	Neem cake	21.82	30.41	31.01	33.56	20.2	41.87	58.91	71.55	45.5	6.5	6.13	2.63	23.71	249.06
T7	Neem cake + carbendazim	27.91	32.57	34.06	35.14	37.97	45.81	62.05	70.12	41.5	6.88	5.81	2.56	26.58	273.75
T8	Neem cake + *Trichoderma harzianum*	21.54	28.24	30.66	33.79	32.62	49.91	64.73	74.85	54.63	8.19	5.06	2.21	25.47	308.12
T9	Neem cake + *Pseudomonas fluorescens*	22.63	27.71	28.3	38.14	29.65	48.19	60.42	70.05	40.75	6.69	5.69	2	30.05	265.44
T10	Neem cake + *Pseudomonas fluorescens + Trichoderma harzianum*	24.01	29.81	30.05	41.31	28.47	46.01	55.77	62.85	35.31	6	5.75	2.31	22.6	258.25
Overal Mean		21.6	28.49	31.89	36.63	25.19	42.56	56.3	65.37	39.49	**6.09**	**5.28**	**2.35**	**24.2**	**257.46**
C. D. (P = 0.05)		5.244	9.176	5.017	9.623	8.471	6.971	7.486	8.636	13.894	**2.104**	**2.226**	**0.802**	**7.289**	**89.018**

Fresh Root Weight (g) at 110 Days after Sowing

The data presented in Table 1, showed that the maximum root fresh weight was recorded in **T_4** *Trichoderma harzianum* (6.75g), follows by, **T_6** Neem cake (6.13g), **T_2** carbendazim (6.06g), **T_7** Neem cake + carbendazim (5.81g), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (5.75g), **T_9** Neem cake + *Pseudomonas fluorescens* (5.69g), **T_5** *Pseudomonas fluorescens* + *Trichoderma harzianum* (5.50g) **T_8** Neem cake + *Trichoderma harzianum* (5.06g), **T_3** *Pseudomonas fluorescens* (4.81g), **T_1** Neem oil (4.12g), including with T_0 control (2.44g). But The treatments T_4,T_6,T_2,T_7,T_{10},T_9,T_5,T_8,T_3 found none significant to each other. T_6, T_2, T_7, T_{10}, T_9, T_5, T_8, T_3, and T_1 were non significant to each other. T_1 and T_0 were statistically none significant to each other.

Dry Root Weight (g) at 120 Days after Sowing

The maximum dry root weight was recorded in **T_4** *Trichoderma harzianum* (3.56g), follows by, **T_2** carbendazim (3.00g), **T_5** *Pseudomonas fluorescens* + *Trichoderma harzianum* (2.75g) **T_6** Neem cake (2.63g), **T_7** Neem cake + carbendazim (2.56g), **T_3** *Pseudomonas fluorescens* (2.38g), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (2.31g), **T_8** Neem cake + *Trichoderma harzianum* (2.21g), **T_9** Neem cake + *Pseudomonas fluorescens* (2.00g), **T_1** Neem oil (1.88g), including with T_0 control (0.63g). But T_4 and T_2 were statistically none significant to each other. T_5,T_6,T_7,T_3,T_{10},T_8 and T_9 found none significant to each other. T_6,T_7,T_3,T_{10},T_8,T_9 and T_1 were none significant to each other.The minimum fresh root weight 0.63g was recorded in T_0 control pots.

Figure 7: Plant Harvested for Fresh and Dry Weight of Shoots and Roots

Root Length (cm) at 110 Days after Sowing

The data presented in Table 1, revealed most of the treatments were statistically significant increased root length as compared to control. 110 days after sowing the tomatoes plants uprooted and the root was measured. The maximum root length was recorded in **T_9** Neem cake + *Pseudomonas fluorescens* (30.05cm), follows by, **T_4** *Trichoderma harzianum* (29.49cm), **T_7** Neem cake + carbendazim (26.58cm), **T_8** Neem cake + *Trichoderma harzianum* (25.47cm), **T_1** Neem oil (24.72cm), **T_3** *Pseudomonas fluorescens* (24.67cm), **T_6** Neem cake (23.71cm), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (22.60cm), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (20.98cm), **T_2** carbendazim (20.70cm), including with T_0 control (17.24cm).But T_9,T_4,T_7,T_8,T_1,T_3, and T_6 were none significant to each other. T_4, T_7, T_8, T_1, T_3, T_6 and T_{10} found none significant to each other. T_6, T_{10},T_5,T_2 and T_0 were statistically none significant to each other.

Yield Plant (g) at 110 Days after Sowing

The data reported in table 1, showed that the maximum yield was recorded in **T_8** Neem cake + *Trichoderma harzianum* (308.12g), follows by, **T_2** carbendazim (294.31g), **T_4** *Trichoderma harzianum* (282.56g), **T_1** Neem oil (279.50g), **T_7** Neem cake + carbendazim (273.75g), **T_9** Neem cake + *Pseudomonas fluorescens* (265.44g), **T_{10}** Neem cake + *Pseudomonas fluorescens* + *Trichoderma harzianum* (258.25g), **T_3** *Pseudomonas fluorescens* (256.86g), **T_6** Neem cake (249.06g), **T_5** *Pseudomonas fluorescens*+ *Trichoderma harzianum* (219.94g), including with T_0 control (144.25g). The treatments T_8,T_2 T_4,T_1,T_7,T_9,T_{10},T_3,T_6 and T_5 were statistically none significant to each other. $T_5$and T_0 found none significant to each other. The minimum products was recorded was recorded in T_0 (144.25g) control pots.

Figure 8: Effect of Bio Agents, Neem Products and Carbendazim with and without Combination on Root Length of Tomato (cm) at 110 DAS

DISCUSSIONS

Similarly found by **Abdel-Kader *et al*.(2013)** reported that all applied bio-agents significantly reduced the recorded foliar diseases comparing with untreated control against early and late blights on tomato plants. Application with either *T. harzianum* and *B. subtilis* showed significant reduction in diseases incidence comparing with the other applied bio-agents. Which is in conformity with **Chandrakala et al. (2012)** concluded from the experiment that culture filtrates of antagonists like *Trichoderma virens*, *Trichoderma viride*and *Pseudomonas fluorescens* having the potential of preventing or inhibiting the germination of *Phytophthora infestans* sporangia causing late blight of potato and also preventing the infection from *Phytophthora infestans* in *in-vitro* conditions.Similarly **Dey et al. (2010)** who reported that biocontrol agents like *Trichoderma harzianum, T. viride, Penicillium* sp. and *Chaetomium*sp. which showed their potentiality against *P. infestans* when applied as prophylactic but proved ineffective when applied as curative.In prophylactic measure conidial suspension of antagonists were sprayed on potato plants seven days earlier to *P. infestans* inoculation.Similarly **Ephrem *et al* (2011)** reported that plants sprayed with *T. viride*, *P. fluorescens* had significantly ($P<0.05$) reduced late blights severity compared to the negative control (inoculated/untreated checks) and the mixed culture. The present findings corroborate the report of **Sharma, P. and. Saikia, M.K. (2013)** observed in the pot experiment that all the fungicides when applied as prophylactic spray significantly reduced the foliage infection of late blight over untreated control. Similarly **Ha Tran *et al*** (**2007)** reported that *Pseudomonas fluorescens* was effective in preventing infection of tomato (*Lycopersicon esculentum*) leaves by *P. infestans* and significantly reduced the expansion of existing late blight lesions.

CONCLUSIONS

Among all the treatments most effective was *Pseudomonas fluorescens* when used as foliar spray and soil treatment against *Phytophthora infestan* showing minimum disease intensity 28.80% and controlled the disease 71.2 % but Neem cake + *Trichoderma harzianum* was found maximum plant height and yield as compared to other treatments.In the shoot dry, fresh weight and yield most effective treatment was Neem cake + *Trichoderma harzianum*. In root dry and fresh weight the most effective treatment was *Trichoderma harzianum* but Neem cake + *Pseudomonas fluorescens* was found maximum root length as compared to other treatments. The data reported in the present thesis are limited to one crop season under Allahabad agroclimatic conditions as such to authenticate the result more such trials should be carried out in future.Based on present findings *Pseudomonas fluorescens* are found effective as a bio-control agent for the management late blight of tomato.

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